strategy.[27] Immediate postoperative management is complementary, with emphasis on minimizing both volume administration and excessive sedation. Long-term anticoagulation management is typically with aspirin alone. Other medical management includes furosemide and afterload reduction, as indicated.

In summary, we present our experience with highly selective use of fenestration during Fontan palliation. The data support a nonfenestrated, extracardiac conduit technique for Fontan palliation, irrespective of anatomic subtype, with fenestration reserved for only the patients at highest risk. Relying on improvements in all areas of medical and surgical management, this strategy results in equal or better surgical outcomes and fewer reinterventions. Further longitudinal follow-up of this patient population, including functional outcomes, will benefit the assessment of this approach for patients with single-ventricle anatomy.

We thank all our team members at Texas Children's Hospital for their tireless dedication to and care of these patients. Without them, these results for our patients undergoing Fontan palliation would not be possible.

CHD

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## Discussion

**Dr Scott M. Bradley** *(Charleston, SC).* You have nicely traced the evolution of your group's strategy through the last 7 years to one that now includes use of an extracardiac conduit, with the use of CPB, minimal use of aortic crossclamping, and decreasing in use of fenestrations (only 6% of patients in the last year). You have shown without question that this strategy can be used with good outcomes, looking at all the usual outcome measures that are examined for Fontan procedures. Both the use of this strategy and your outcomes are in line with what has been described in previous publications, for example, those from the Stanford/University of California San Francisco experience and from the Los Angeles Children's Hospital experience.

I have several questions. The first has to do with the duration of pleural effusion drainage in your study, which ran about 6 days. This was discussed in the debate yesterday, but there is certainly a great deal of variation in the literature; some of this variation is undoubtedly related to differences in management protocols for chest tubes after Fontan procedures. Could you elaborate on your group's approach to postoperative management of chest tubes? Specifically, when do you decide to remove chest tubes? Do you have any consistent approach to the use of medications to try to cut down on effusion drainage, such as angiotensin-converting enzyme inhibitors and diuretics?

**Dr Salazar.** Our strategy for decreasing chest tube output begins with aggressive ultrafiltration in the operating room, minimization of fluid administration in the postoperative period, and a policy of early extubation. With regard to timing of chest tube removal, all of us at Texas Children's Hospital are conservative and prefer to leave the tubes in until minimal output has been demonstrated. Diuretic administration is routine, preferring to see a mild increase in blood urea nitrogen as a result of our diuretic management. Furthermore, patients are fluid restricted to half or three-quarters maintenance total fluid intake for at least the first week after surgery.

**Dr Bradley.** Do you have any specific amount of chest tube drainage that you use to decide when to take the chest tubes out?

**Dr Salazar.** I prefer to tailor that decision to the specific patient, taking into account the clinical situation. As a general rule, we do not remove drains until output has decreased below 1 mL/(kg · d).

**Dr Bradley.** It appeared that approximately a quarter of your patients were readmitted. I assume that some of these were for treatment of effusions?

**Dr Salazar.** Correct. Readmission was defined as occurring any time within 1 month of discharge, to capture late readmissions. More than half of those readmissions were for pleural effusion management. Interestingly, the percentages of patients requiring readmission for effusion in the fenestrated and nonfenestrated groups were equivalent.

**Dr Bradley.** If you were to include that period in the duration of pleural effusion drainage and the stay data, both of those pieces of information would probably look a bit different. That may be something you would want to consider putting in the article.

You now fenestrate very selectively. How do you decide in which cases to fenestrate? Do you decide preoperatively or in the operating room, and what specific criteria do you look at?

**Dr Salazar.** The decision to fenestrate is a clinical judgment made in the operating room. Patients known to be at higher risk, such as those receiving single-lung Fontan palliation, those with severe atrioventricular valve regurgitation, and those with high pulmonary vascular resistance are most likely to have fenestration.

The conduct of the operation also influences the fenestration decision. If a significant period of cardiac arrest or even circulatory arrest is required (although this is rare), then fenestration is more likely. Fenestration is used to improve the early outcomes after the Fontan operation. If preoperative and intraoperative variables suggest a risk compromising the patient's early postoperative course, then we would fenestrate. Ultimately, it is a clinical judgment that is based on the experience that fenestration is usually not necessary.

**Dr Bradley.** So it sounds like a general gestalt of the patient's characteristics and how things are going in the operating room, as opposed to specific hemodynamic criteria?

**Dr Salazar.** Ultimately, I agree.

**Dr Bradley.** Fair enough. Finally, I think it's a bit more difficult to fenestrate reliably extracardiac conduits than intra-atrial lateral tunnels. Can you comment on your group's technique?

**Dr Salazar.** Our technique is to fenestrate extracardiac conduits with the heart beating. We use a partial occlusion clamp on the GORE-TEX conduit and atrium. An aortic punch is used for the GORE-TEX conduit fenestration, although the depth of sutures on the atrial side can influence the effective size of the fenestration.

**Dr Bradley.** So it's side-to-side between the atrium and the outside of the GORE-TEX graft, as opposed to using a second tube graft between the two?

**Dr Salazar.** That's correct.

**Dr Bradley.** I think you have some information in your article about the reliability of fenestration, specifically looking at postoperative systemic oxygen saturation. Can you just comment on the postoperative oxygen saturation difference between the patients with and without fenestration?

**Dr Salazar.** Most of the patients with fenestrated Fontan procedures underwent the lateral tunnel technique. The lateral tunnel baffle was fenestrated with an aortic punch, typically ranging in size from 3 to 4 mm.

Interestingly, the discharge oxygen saturations were similar in the patients with and without fenestration. This may reflect a less ill patient population referred for Fontan palliation relative to 10 years ago. Decreasing preoperative transpulmonary gradients and pulmonary vascular resistance, coupled with operations that minimize the negative physiologic impact of surgery, have likely led to less shunting across the fenestration.

**Dr Bradley.** So the numbers were, say, 92% versus 94%?

**Dr Salazar.** Average discharge saturations were 91% with fenestration and 93% without fenestration.

**Dr Francois Lacour-Gayet** *(Aurora, Colo).* I enjoyed your presentation. I understand that the rule now is no fenestration. Do you believe that there is an exception for altitude? In Denver, we fenestrate all our Fontan procedures and would not dare not to fenestrate. Can you elaborate on this and perhaps give us a limit, an altitude at which you would consider not to fenestrate?

**Dr Salazar.** I appreciate your question, Dr Lacour-Gayet. Not having lived or operated in Denver, I won't presume to make a general recommendation for the city. Having said this, the decreased partial pressure of oxygen at altitude likely translates into some increase in pulmonary vascular resistance and reactivity. I would proceed cautiously and base recommendations on clinical experience.

**Dr James S. Tweddell** *(Milwaukee, Wis).* You were talking about aggressive use of diuretics. What specific diuretics are you using?

**Dr Salazar.** Most of the time, we use furosemide alone for postoperative diuresis. Our dose typically is 1 mg/kg, administered 2 or 3 times a day. Some may not consider that aggressive, but that is what I'm talking about.

**Dr Tweddell.** Did you ever consider using spironolactone in addition?

**Dr Salazar.** We have used spironolactone in addition to furosemide for those few patients with prolonged chest tube drainage.

**Dr Frank L. Hanley** *(Stanford, Calif).* When you do your side-to-side fenestration with the punch and then you put the atrium against that hole, do you put your sutures directly into the edge of the punch when you're actually making the surgical connection?

**Dr Salazar.** You mean to the inside?

**Dr Hanley.** When you're bringing the atrium to the GORE-TEX—I presume you use GORE-TEX?

**Dr Salazar.** Yes.

**Dr Hanley.** Are the sutures that go through the GORE-TEX going through the edge of the hole? I mean, are the sutures going into the actual hole of the 4-mm punch?

**Dr Salazar.** Yes, I typically take thin bites of atrium and GORE-TEX to avoid compromising the effective size of the fenestration.

**Dr Hanley.** If I could just make a suggestion?

**Dr Salazar.** Please do.

**Dr Hanley.** We used to do that, too. When you do that, if you pick up too much of the atrium or the atrium is bulky, which is not uncommon in a single ventricle, you will get a tunnel effect to the fenestration because the atrial tissues impinge on the punch hole, making the size of the hole unreliable. We prefer to put a large, side-biting clamp on the GORE-TEX tube and then make the 4-mm punch inside the relatively large surface area of GORE-TEX sequestered by the clamp. We put another large, side-biting clamp on the atrium, sequestering a relatively large surface area of atrium as well. Then we make a long atriotomy, maybe 2 cm, and sew the cut edge of the atrium onto the sequestered surface of the GORE-TEX graft, at least half a centimeter if not more away from the edge of the punch hole, onto the flat surface of the GORE-TEX. So in the end, if you were sitting in the atrium and looking at that atrial incision, you would see a 1.5-cm circle or oval of GORE-TEX with a 4-mm punch in the middle of it. It is an undistorted true 2-dimensional fenestration.

**Dr Salazar.** You have not had any problems with clots forming in that area?

**Dr Hanley.** Not to our knowledge.

**Dr Tweddell.** I would just say that we use exactly the same technique. And actually I use the inferior vena cava, or the atrial end of the inferior vena cava. You can use that to sew around the fenestration, just as Dr Hanley suggested, and we have not seen any consequences. It gives you a reliable fenestration.

**Dr Salazar.** Thank you, and your point is well taken. The good news is that, excepting the possibilities at high altitude, fenestration of extracardiac conduits is rarely necessary.